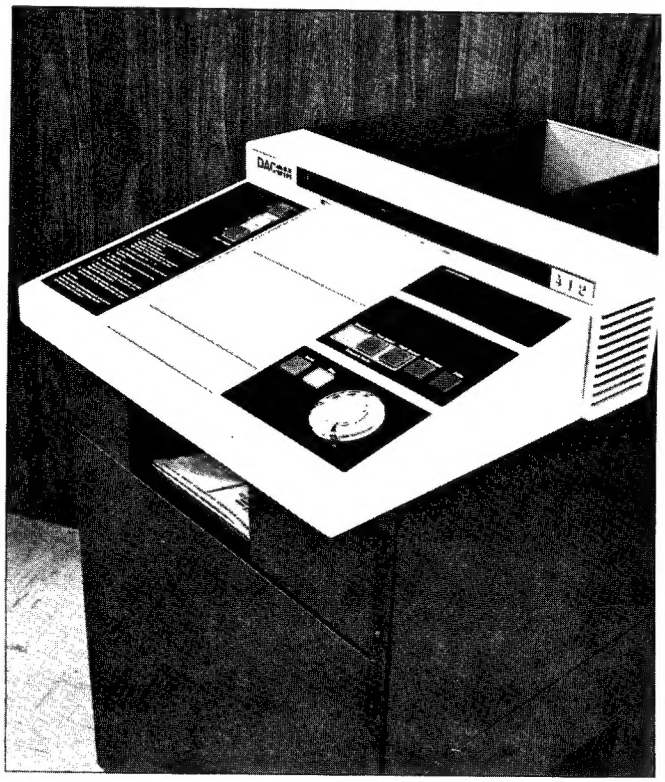
DACOM

MODEL 412 SECUREFAX

Digital Document Facsimile Transceiver



- SUB-MINUTE TRANSMISSIONS
- NON-CONDITIONED VOICE GRADE LINES
- OPERATES OVER DDD NETWORK
- UNATTENDED RECEIVE OPERATION
- SELECTABLE RESOLUTION
- FLAT BED SCANNER
- CONNECTS TO DAA
- CRYPTO INTERFACE
- ELECTROGRAPHIC PRINTER
- EASY TO OPERATE

The Dacom *Model 412* is a new and unique facsimile transceiver employing data compression. It has operating characteristics which collectively surpass any other equipment available today. System features include digital transmission, high speed, high quality, extensive automation, secure mode, internal paper supply, adaptively equalized modem, and reasonable cost.

The *Model 412* was designed to provide fast transfer of letter size documents between offices using ordinary telephone lines. The cost per page is approximately the cost of a special delivery letter.

Installation consists of connecting the unit to a telephone line through a DAA (Data Access Arrangement) which is furnished by the telephone company and costs only a few dollars a month. For secure communications crypto equipment must be provided. The *412* is supplied with the necessary interface connections for crypto units.

Any number of *412* transceivers may be connected in a network. The circuits may be WATS lines, tie lines, private lines, Autovon, microwave, satellite, or simply direct distance dialing like an ordinary telephone.

SYSTEM DESCRIPTION

The Dacom *Model 412* is a complete operating facsimile transceiver in a console configuration, based on advanced state-of-the-art technology throughout. Electronic circuitry has been reduced largely to LSI/MOS chips. Digital data compression results in exceptional speed and quality performance characteristics. A new modem with adaptive equalization permits full speed transmission through switched, non-conditioned voice grade lines, as well as two way coordination, status, annunciation and control. Verification of receipt of message is automatic. An electrographic stationary stylus printer produces high contrast copies on white, bond like dielectric paper.

The *412* is intended for automatic transmission of most types of graphic forms such as typewritten and handwritten letters, charts, drawings, sketches, diagrams, and maps in both clear and crypto modes. An 8½" X 11" document may be transmitted in less than one minute with a received resolution of 200 lines per inch in the horizontal dimension and 100 lines per inch vertically. Alternate resolutions available are 200 lines per inch vertically when finer resolution is desired, and 67 lines per inch when speeds in the 30 second range are required. The horizontal resolution is always 200 lines per inch. Pushbuttons on the console may be used to select resolution, page size, multipage mode or compensate for a noisy line. An automatic stack feeder (optional), automatic answer and internal paper supply permit operation with a very minimum of operator attention.

Operation is extremely simple, about the complexity of operating an office copy machine. Place the document face down on the console and move it forward to activate the system. Pick up the telephone and dial the desired number. When an answer tone is heard, hang up the telephone – that's all. The machines then "handshake" for a few seconds, verifying line conditions, equalizing the modems, and automatically establishing set-up functions (paper size, resolution, data rate, etc.). The "Transmit" light turns on and the document moves through the scanner (always in sight), then drops into a tray. After transmission the light goes out and both machines "hang up". If the "multipage" button has been pushed, the line is held open so that redialing is unnecessary. "Handshaking" occurs between each document to assure that every document is transmitted successfully.

At the receive terminal the machine automatically answers, prints the page, deposits it in a tray, informs the sending station that the document was received and readies itself for the next message. No operator needs to be present.

TERMINAL SPECIFICATIONS

Document Size	Any size up to 8½" wide by 14" long
Communication Line	Voice Grade, switched, non-conditioned line
Line Interface	Interfaces with Data Access Arrangement (DAA)
Secure Mode	Complies with MIL-STD-188C (±6 V Polar)
Scanner	Flat bed, optical, 200 lines per inch
Copy paper	(1,000 ft.) roll, white, dielectric, 8½" wide, cut to length, 5½", 11" or 14"
Transmission Time	Average density text, 8½" X 11" page:

Vertical Resolution	Horizontal Resolution	Speed
67 lpi	200 lpi	35–45 sec.
100 lpi	200 lpi	50–60 sec.
200 lpi	200 lpi	1½–2 min.

Modem	4800/2400 bps adaptively equalized, half duplex (full duplex optional)		
Power per Terminal	115 VAC, ±10%, 50/60 Hz, 9A, single phase (230 V optional)		
Console Size	Height–39"	Width–25"	Depth–33"
Console Weight	375 lbs.		
Modem Size	Height–5¼"	Width–19"	Depth–19½"
Modem Weight	30 lbs.		

14K W/ MODEM
10K - TERMINAL
300/MP

For further information contact:

DACOM

Dacom,Inc., 1060 Morse Ave., Sunnyvale, California 94086 Phone (408) 734-3710

digital-fax its significance to the military

by
Robert S. Meltzer
Marketing Director
Dacom, Inc.

and

William V. Taylor
Manager Defense Sales
Dacom, Inc.

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FACSIMILE HAS BEEN used by the military for many years, but its widespread application, except in specialized areas, has been amazingly slow in coming. On a superficial level this is surprising since facsimile offers the military user a number of unique advantages of particular importance and usefulness relative to the military mandate and mission.

Facsimile can minimize the time interval in completing one of the most vital military communication tasks—the delivery of a message for action and implementation.

The great bulk of written military communications is accomplished using teletype devices. Teletype will continue to be used because its vast switched network is installed and in operation, people know how to use it, and it does the job. However, compared to facsimile, teletype has two basic limitations: 1) It requires a skilled human operator, 2) It cannot transmit graphics. The human operator is deficient in two basic areas: 1) He introduces a time delay because he is relatively slow, and 2) he makes errors. Facsimile avoids these problems. The information on a document requires no further preparation, and human induced errors are non-existent. Of course, both teletype and facsimile are subject to communication line errors or garbling, but a garbled facsimile signal will not misspell a word or modify the meaning of a sentence. Not so with teletype.

Optical character recognition (OCR), a relatively recent arrival, has been used to circumvent the teletype problems mentioned above. OCR has the advantage of phenomenal speed. Errors, while existent, can be identified and limited to a certain extent. However, with OCR another problem is experienced. The more versatile its reading ability, the greater the complexity and thus the expense of the terminal equipment. A given OCR device is programmed to read a pre-determined variety of letters, numbers and symbols. A character of different shape or size will be re-

jected. Enlargement of the repertoire of readable characters is possible only at increased cost. In facsimile, the information appearing on documents is scanned microscopically and transmitted regardless of its design or geometric shape; errors in electronic interpretation do not occur. Furthermore, facsimile is enormously more flexible than OCR or teletype since it can convey maps, sketches, drawings, and handwritten copy in addition to alphanumeric and symbolic information. Facsimile is fluent in all languages, including Japanese, Chinese and others that pose real problems with conventional communication terminals. Of course, other types of communication media are used to move information, such as, mail, courier, telephone and television, but the application distinction vis-a-vis facsimile are more evident than with teletype and OCR.

Facsimile has one more advantage over other electronic means for transmitting messages and documentary information—it is potentially lower in overall cost. Simply put, if the cost of operator time, terminal equipment, line costs, and other communication expenses are taken into account the cost per message with facsimile will often come out ahead.

With all the advantages cited above, why is it that facsimile has not played a more prominent role throughout military communications and not just in specialized areas? The reason is that facsimile, up to the present time, has been deficient in a number of significant areas. A discussion of these deficiencies and how they have been overcome in newly introduced digital data compression facsimile equipment is the subject of this article. While not all the deficiencies discussed below are concentrated in any one type facsimile unit, one or more of these problem areas is usually found evident in any model examined.

Analog Facsimile

Excessively long transmission time has been one of the most annoying characteristics of equipment to date. Most standard facsimile terminals are analog in design and require approximately six minutes for a "standard transmission." Since there are a great variety of modes in which a facsimile unit can operate, one must be careful to define the assumptions underlying a stated parameter. When we speak of standard transmission we are referring to transmission of an 8½ x 11 inch page over a non-conditioned voice grade line (600-2700 Hz), with a horizontal and vertical resolution of approximately 100 scan lines per inch which is adequate for reading typewritten material.

It should be noted that there are units recently placed on the market which are capable of standard transmission of three minutes or less. However, it is the authors' understanding that such units are more liable to distortions caused by line interference than the six minute versions, and the most successful applications have occurred over relatively short distances or over lines with especially good quality.

The time taken to transmit multiple pages at six minutes per page causes diversion of line from voice use for excessive periods, increases communication line costs, and unduly occupies operator time.

A second prominent obstacle to greater military use of facsimile is in the area of copy quality. Copy quality can be viewed by two criteria: 1) line resolution, and 2) page appearance. The resolution of a standard transmission is completely satisfactory for about eight point type or larger (about what one would find on an ordinary typewritten page). Any smaller type would often be difficult to read. Telephone page listings or newspaper baseball scoreboard information for example would be close to indiscernible. Since a great deal of printed matter is composed of very small type, such material simply cannot be successfully conveyed by a "standard" analog facsimile transmission.

The other part of the copy quality question is paper appearance. While much progress has been made in this area it is fair to say that many of the facsimile machines operating today utilize paper which is typically gray, crinkly, limp, difficult to file, and aesthetically less than pleasing.

Imposition of security provisions have always constituted a non-trivial set of problems for communication equipment. This is particularly true for facsimile terminals. Problems have occurred in two areas. The first has been the degrading effect of processing analog facsimile signals through crypto equipment. The second difficulty has come about in trying to eliminate the radiation of intelligible radio frequency emissions from the facsimile terminals. With respect to the question of radio frequency emission suppression, the facsimile industry has always solved this problem when required, however, it has most often been done with a significant cost penalty.

Government encryption equipment is normally digital in nature. Roughly speaking, the bits of a digital stream within the crypto equipment are "scrambled" for transmission over the communication line and then put back in the original bit stream order at the decoding station. In order to be scrambled, the analog signal from the facsimile scanner must be converted to a digital form. Ordinarily, such conversion entails a bandwidth expansion. If extra bandwidth is not available, such as when voice grade telephone lines are used, then the signal must be degraded to some extent. The net result of this analog to digital conversion process is often degraded received facsimile copy.

Other factors which have also served to curtail the use of facsimile within the military, have been lack of compatibility between facsimile types, manual operation of some models, sensitivity to communication line interferences, and problems in reliability and maintenance. It should be again emphasized that the array of problem areas mentioned above by no means exists in all machines. However, it should also be stated that when an attempt has been made with analog systems to eliminate, or substantially reduce, all of these limiting characteristics, the resulting terminal costs have made the use of such units justifiable only in instances in which expense is not a prime factor.

Digital Data Compression Facsimile

The emergence of secure digital facsimile as a practical, cost effective medium with features far exceeding older facsimile designs is the result of the development

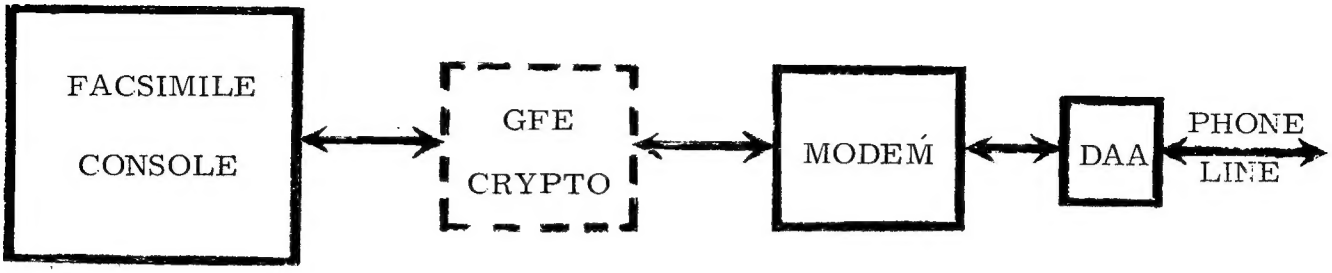

Fig. 1. Digital Facsimile Terminal

and practical application of a number of new and exciting technologies. These developments, related directly to advancements in digital equipment and techniques are:

1. Miniaturization and fabrication of electronic components employing large scale integration and metal oxide simi-conductors (LSI/MOS).
2. The development and practical implementation of extremely efficient data compression algorithms (codes.)
3. The development of high speed modulation/demodulation devices (modems) capable of operating at low error rates over switched nonconditioned voice grade lines.

At the same time that these developments have taken place the whole telecommunications transmission facility is being converted with increasing rapidity from analog to digital. Digital facsimile is able to take advantage of a myriad of performance flexibilities and cost benefits resulting from the change over.

Description of Digital Facsimile Terminal

The digital data compression system employs the same basic functional components as analog equipment, with the distinction that digital components and techniques serve to enhance system performance characteristics.

A scanning device picks up light reflected off the original document. The signal from the scanning detector is converted into a digital bit stream. The bit stream is then introduced into the compression circuitry where a code is applied to reduce the number of bits necessary to convey the scanned information. The output of the compressor is directed to the transmit section of the modem where it is changed into a modulated carrier for transmission over a conventional telephone channel. At the receive terminal the complementary functions occur. The digital output of the modem is expanded in the data reconstructor to its original bit stream to activate a printing mechanism. Figure 1 shows a diagram of the functional elements of a digital facsimile terminal. Note: For secure applications, a crypto unit is placed between the facsimile system and the associated modem as shown. When operated over the direct distance dialing (DDD) switched network, a Data Access Arrangement (DAA), is also employed.

Speed

The combined effect of data compression and high speed modem technology substantially reduces transmission time. For the "standard" transmission of the new digital facsimile, a 250 word typewritten message can be transmitted in less than one minute, or a 600 per cent improvement over the typical analog facsimile unit in use today.

Note: Such speeds are routinely achieved over trans-continental distances at modem rates of 4800 bits per second using voice grade DDD telephone lines.

This increase in speed significantly enhances the possibility of real time facsimile in many applications. For example, while previously a ten page plan or report would require one hour of transmission time, a digital compression facsimile system takes less than ten minutes. The high speed permits visually-aided telephone conversations at costs far lower than closed circuit TV.

Copy Quality

One of the most useful benefits of digital data com-

pression, in addition to speed, is its ability to provide increased resolution with minimum time or bandwidth penalty. In order to transmit fine line information or small text, resolutions higher than 100 lines per inch are needed. If the resolution is increased in an analog facsimile machine from 100 lines per inch to 200 lines per inch in both horizontal and vertical, the number of "dots" which must be transmitted increases by a factor of four. Thus, a six minute transmission at 100 lines per inch would increase to a 24 minute transmission time at 200 lines per inch, over the same telephone channel.

In some digital data compression systems, however, for reasons which go beyond the scope of this discussion, time increases only by a factor two. Since the transmission time is low to begin with, this factor of two imposes a minimum time penalty. That is, a one minute transmission at 100 lines per inch becomes only a two minute transmission at 200 lines per inch. Thus digital data compression facsimile systems overcome the severe time limitation imposed when transmission of fine detail is desired. At 200 lines per inch with transmission times of two minutes or less, pages with information barely discernible to the human eye can be transmitted and reproduced legibly. Since military maps, diagrams, drawings, and printed material often contain such fine detail, much more data can now be successfully transmitted over voice grade lines in a reasonable time.

Secure Communications

Because the output of the new facsimile systems are digital in format, they suffer no degradation whatsoever when processed through standard government-furnished encryption equipment. In addition, problems of interface, synchronization and signal "handshake" are minimized because both the facsimile and crypto equipment are of the same digital character.

In the area of meeting government standards for radio frequency emission, digital circuitry, and LSI "chips" have a real advantage. The low voltages utilized have inherently low radiation characteristics. If solid state or quasi-solid state scanning and printing devices are used, then the radiation problems are further minimized. Under ideal circumstances no external shielding would be required to meet federal standards for secure operation. One of the severest problems has thus been set aside if the equipment can be made to meet federal standards with relative ease.

Flexibility

One of the most impressive characteristics of recently appearing digital facsimile systems is flexibility of performance and compatibility with other equipment and systems. The flexibilities include its ability to operate without modification over varying bandwidths, its ability to operate over digital transmission networks as well as the normal analog circuits, its compatibility with store and forward devices, switching systems, polling, broadcast routines and error correction techniques.

Digital data compression facsimile systems of the type discussed here are "slaved" from a speed standpoint to the clock rate provided by the associated digital modem or an externally provided clock. If the terminal is required to operate over a narrow band or low quality channel, the clock rate can be reduced so that the equipment operates at a low transmission rate sufficient to communicate without excessive error. Equipment of this type has been operated for the U.S. Navy over HF radio links at bit rates as low as 75 bits per second. No degradation of copy quality occurs even at these low transmission rates and accompanying narrow bandwidths.

One of the intriguing applications recently demonstrated by the Defense Communication Agency (DCA) is the use of digital facsimile over digital networks such as AUTODIN. The advantages of operating digital facsimile over AUTODIN are that first, being a military switched network, most recipients of messages will be near message centers. Also, the network is secure, and finally, AUTODIN is designed for very low error rates, so that communication interference problems occurring on ordinary telephone lines do not normally occur. Thus problem free reliable transmission is assured.

Computer Compatibility

The output of a digital facsimile may be stored on any of the media upon which computer output is stored. This includes magnetic tape, disc, or solid state memory. With compression, the efficiency of storage increases in proportion to the compression ratio. Storing and forwarding of fax messages is similar to store and forward systems for computer or teletype data. Other computer oriented functions such as message switching, polling of terminals, broadcast transmission, and error correction can be used with digital facsimile terminals. By employing such operations, a communication network can compensate for the variations in communication line loading, and thus accommodate a greater volume of digital traffic through the system. The use of these techniques permits much more economic operation of the network. The digital facsimile system fits smoothly into the computer-switched systems which are now being so successfully applied in many military communication areas.

The military must constantly search for the best, most advanced, yet cost effective, means available for accomplishing its vital missions. In the area of facsimile, newly introduced digital equipment offers to satisfy this requirement.

Greater resolution and better copy quality provide a wider diversity and depth of information to the recipient. This, coupled with a high transmission speed, results in vastly improved human communications and decision making. Compatibility with existing computer-controlled communication systems means that the benefits of these new systems can be readily applied to facsimile.

Consequently, digital data compression facsimile equipment may be expected to have wide and rapid acceptance in military communications.

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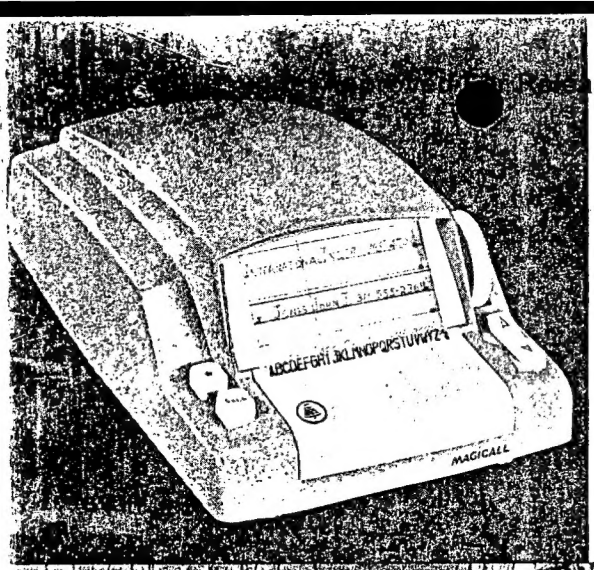

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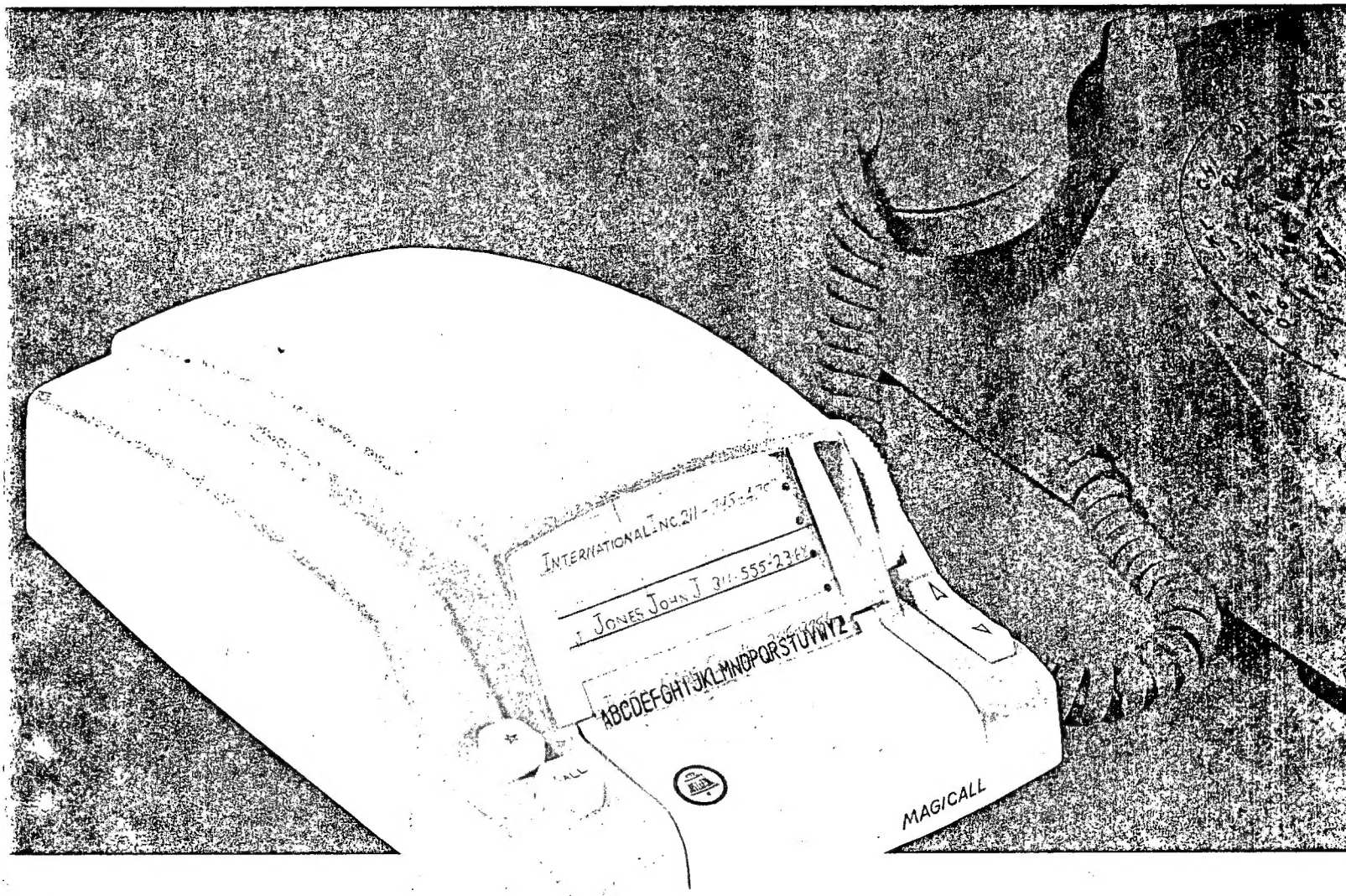

to call, merely locate desired number on motorized index, listen for dial tone, then push "call" button...

gives your business these benefits...

☐ SAVES TIME

- Makes telephoning effortless, accurate, more convenient.
- Easily dials all kinds of calls — local, long distance and intercom.

☐ "REMEMBERS" TELEPHONE NUMBERS

- No need to look up numbers — they are stored on magnetic tape and visibly indexed.
- Numbers may be easily recorded and changed.
- You avoid the "memory tricks" that sometimes mean delays or wrong numbers.

☐ MOTORIZED INDEX

- Permits rapid scanning and fast number selection.

☐ FLEXIBLE CAPACITY

- Individual tape cartridges provide 400 or 1,000 number capacity.
- Several cartridges may be used to give additional capacity as needed.
- Cartridges are easily and quickly interchangeable.

☐ OTHER "PLUS" BENEFITS

- Requires little desk space — small, compact.
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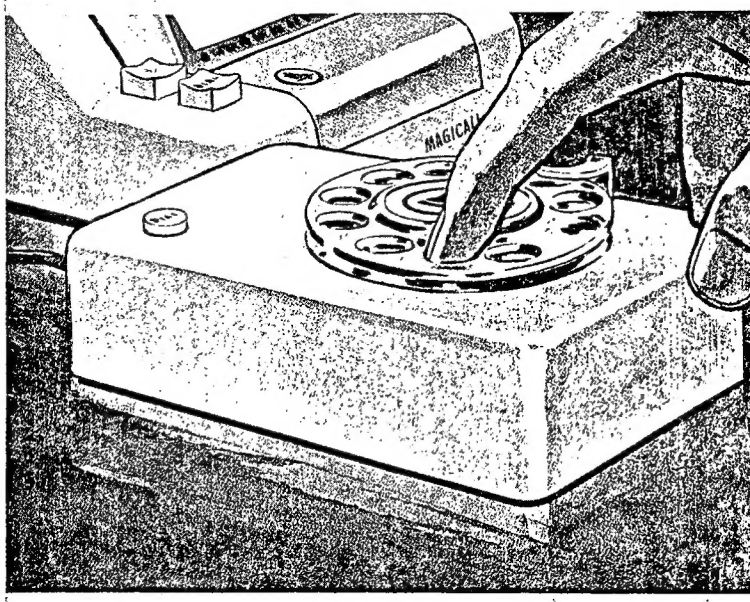
FOR THE OFFICE WORKER making many outgoing calls, helps reduce fatigue, increase efficiency.



HANDY PLUG-IN DIAL, used to record numbers on magnetic tape, stores in desk drawer or other out-of-the-way place when not in use.

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